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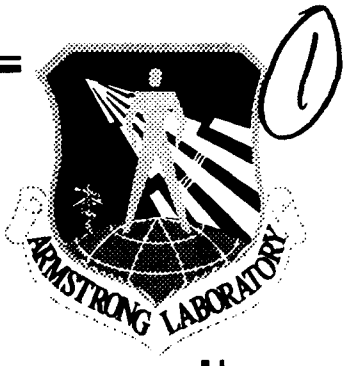

ARMSTRONG LABORATORY

DEVELOPMENT OF A 3-D ACOUSTIC ORIENTATION SYSTEM (3-D AOI)

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Subcontractor (Southwest Research Institute) provides a chronology of the execution of Task 0031, including the process of selecting the Auditory Localization System (ALS) for the 3-D AOI, the process of designing the 3-D AOI and an improved conventional AOI, and the testing of the AOI actually realized. Because of the inability of the ALS vendor to supply software for generating auditory elevation cues until the end of the contract, the 3-D AOI was not evaluated in flight. However, the improved version of the conventional AOI was thoroughly tested in fight, and test data were delivered to the Air Force for analysis.

Acoustic orientation
Auditory localization
Aural displays

Flight instrumentation

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Unclassified

Unclassified

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The Office of Public Affairs has reviewed this report, and it is releasable to the National Technical Information Service, where it will be available to the general public, including foreign nationals.

This report has been reviewed and is approved for publication.

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DEVELOPMENT OF A 3D ACOUSTIC ORIENTATION SYSTEM (AOI)

Selection of Auditory Localization System (ALS)

Three auditory localization system (ALS) candidates were reviewed by the Air Force for possible use in the 3D AOI system. The ALS system selected was built by Systems Research Laboratory (SRL) in conjunction with the Bioacoustics group at Wright-Patterson AFB. This system consists of a helmet mounted headtracker unit which, in conjunction with the localization unit, places the auditory cue in three-dimensional space relative to the subject's head. For the purpose of the 3D AOI flight testing, it was decided to make the sound relate to the sound relative to the attitude of the aircraft. To accomplish this, relative azimuth and elevation angles had to be calculated by the 3D AOI processing unit and sent via a serial connection to the ALS. A serial simulation program was written and installed on a portable computer and two Southwest Research Institute (SwRI) engineers traveled to Wright-Patterson AFB to evaluate the feasibility of using the ALS unit in this non-standard manner. Testing revealed some minor problems with this approach. SRL engineers agreed to solve these problems with a software upgrade.

It is important to note that the ALS system evaluated at the time was not a true 3D system. This system had the capability of synthesizing acoustic cues in azimuth only. SRL was working to correct known and unknown bugs in the head related transfer equations. These equations are crucial for synthesizing elevation cues. SRL engineers were confident that these problems could be solved and promised software upgrades when available.

Design of a 3D AOI

The original concept for the 3D AOI system architecture was to connect the existing 2D AOI unit to the ALS. Development of the 2D unit was begun in late 1988 and was based on a single state-of-the-art (at the time) sound generator chip. In April of 1990, National Instruments released a 16-bit, 35 Mhz DSP board for the Macintosh family of computers. This board represented a substantial leap in audio synthesis technology. In order to take advantage of this new technology, a decision was made to use the knowledge gained from the development of the existing 2D AOI to aid in redesigning the system using the National DSP board and the Apple Macintosh (Mac). The redesigned Mac-based 2D AOI would be used for flight testing and would then be modified for use in the 3D AOI system. In essence, this meant that the 2D and 3D system designs would run concurrently.

System software design was started in July of 1990. The system software was written in a graphical based programming language called LabView. The system was written in a top-down modular fashion with each module capable of being individually tested. The 2D and 3D systems shared many common modules with the exception of modules dealing with flight parameter to acoustic cue parameter mapping. For details of the system software, please refer to the Design, Fabrication, and Testing of a 3D Acoustic Orientation Instrument (3D AOI) report dated April 19, 1991.

The system hardware design consisted of connecting third party vendor supplied pieces of equipment together. In addition, a rack was constructed at SwRI for mounting the system in the research aircraft. For details of the system hardware, please refer to the Design, Fabrication, and Testing of a 3D Acoustic Orientation Instrument (3D AOI) report dated April 19, 1991.

Testing and Evaluation of the 3D AOI

In December of 1990 the AOI system was moved from SwRI to Brooks AFB for pre-flight evaluation and testing. Testing and evaluation was completed approximately three weeks with no major problems encountered.

In January of 1991 work was begun installing the AOI system rack in the research aircraft. Non-subject test flights were begun in mid-January and preliminary subject test flights were begun in early February. The official data gathering 2D AOI test flights were started on February 15, 1991 and were completed March 18, 1991.

Upon completion of the 2D AOI flight tests, the 3D system software was loaded and preliminary flight testing was done. Due to limitations of the ALS software, only azimuth information was used during these tests. In April of 1991, four subject flight tests were conducted using two subjects from the 2D AOI flight tests. No flight data was recorded; however, the subjects were asked to compare the 2D system with the 3D system. Both subjects reported an improvement in their ability to interpret lateralized acoustic cues using the 3D AOI system.

The upgraded ALS software containing the elevation cues was received in April of 1991, but due to flight testing obligations, was not installed until May of 1991. Preliminary testing revealed apparent problems with the serial communications code and due to time constraints, the new software could not be properly evaluated.